AD-A063 255 HAWAII UNIV HONOLULU F/G 14/2

AUTOMATIC ANGULATION STUDY.(U)

AUG 78 J T JEFFERIES F19628-76-C-0144

UNCLASSIFIED AFGL-TR-78-0149 NL

1 OF 1

AD
A063255

END
DATE
FILMED
3--79
DDC

18 19

AFGL-TR-78-0149

6

AUTOMATIC ANGULATION STUDY.

John T./Jefferies

10

University of Hawaii, ~~IfA~~
2680 Woodlawn Drive
Honolulu, Hawaii 96822

9

Final ~~Report~~
1 Mar[redacted]76 - 28 Feb[redacted]78

11

23 Aug[redacted]78

12 14p.

15 F19628-76-C-0144

Approved for public release; distribution unlimited

16 ILIR 17 6D

This research was supported by the Air Force In-House Laboratory Independent Research Fund

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-78-0149	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AUTOMATIC ANGULATION STUDY		5. TYPE OF REPORT & PERIOD COVERED Final Report for Period 1 Mar.76 - 28 Feb. 78 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John T. Jefferies		8. CONTRACT OR GRANT NUMBER(s) F 19628-76-C-0144
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Hawaii, ~~IFA~~ 2680 Woodlawn Drive Honolulu, HI 96822		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61101F ILIR6DAA
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Research Lab. Hanscom AFB. Massachusetts 01731 Monitor/T. Wirtanen/LWG		12. REPORT DATE 23 August 1978 13. NUMBER OF PAGES 14
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) For Public Release; distribution is unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES This research was supported by the Air Force In-House Laboratory Independent Research Fund		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Angulation Measurement of Angles		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes a prototype instrument designed and constructed to demonstrate the feasibility of automatically measuring horizontal angles in the field. Instrumental problems discovered in testing are described.		

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

79 01 15 013

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

INTRODUCTION

This report covers the development work on an instrument designed to measure horizontal angles--the measured angle being defined by the instrument at the vertex, and illuminated targets, positioned on the lines, determining the angle. The instrument is to measure the angle by observing the relative heading to each illuminated target and differentiating. The relative heading measurements are carried out automatically with operator influence being exerted primarily from a calculator keyboard.

The heading measurements are accomplished by combining fine and coarse measurements. The coarse measurement process utilizes a precise circle with 1-degree resolution, and the fine measurement process utilizes an electromechanical position sensor in the focal plane of the telescope which is carried on the precision circle.

A. INSTRUMENT DESCRIPTION

The instrument consists of an optomechanical assembly, an electronics assembly and a Hewlett-Packard 9815A desk calculator with standard BCD Interface. These components are pictured in Figure 1, left to right. All components fit into a shipping case of approximately thirty cubic feet.

1. Opto-Mechanical Assembly

The opto-mechanical assembly is effectively the instrument head which would set over the vertex of the angle to be measured and consists of several sub-assemblies.

(a) Lower Az Motion

The lower Az motion has a range of approximately 120 degrees. The motion is controlled by a gear motor and brake, and is encoded by an incremental optical encoder with a resolution of approximately 4 arc-minutes. This axis allows the use of different portions of the precision circle in the measurement of the same angle.

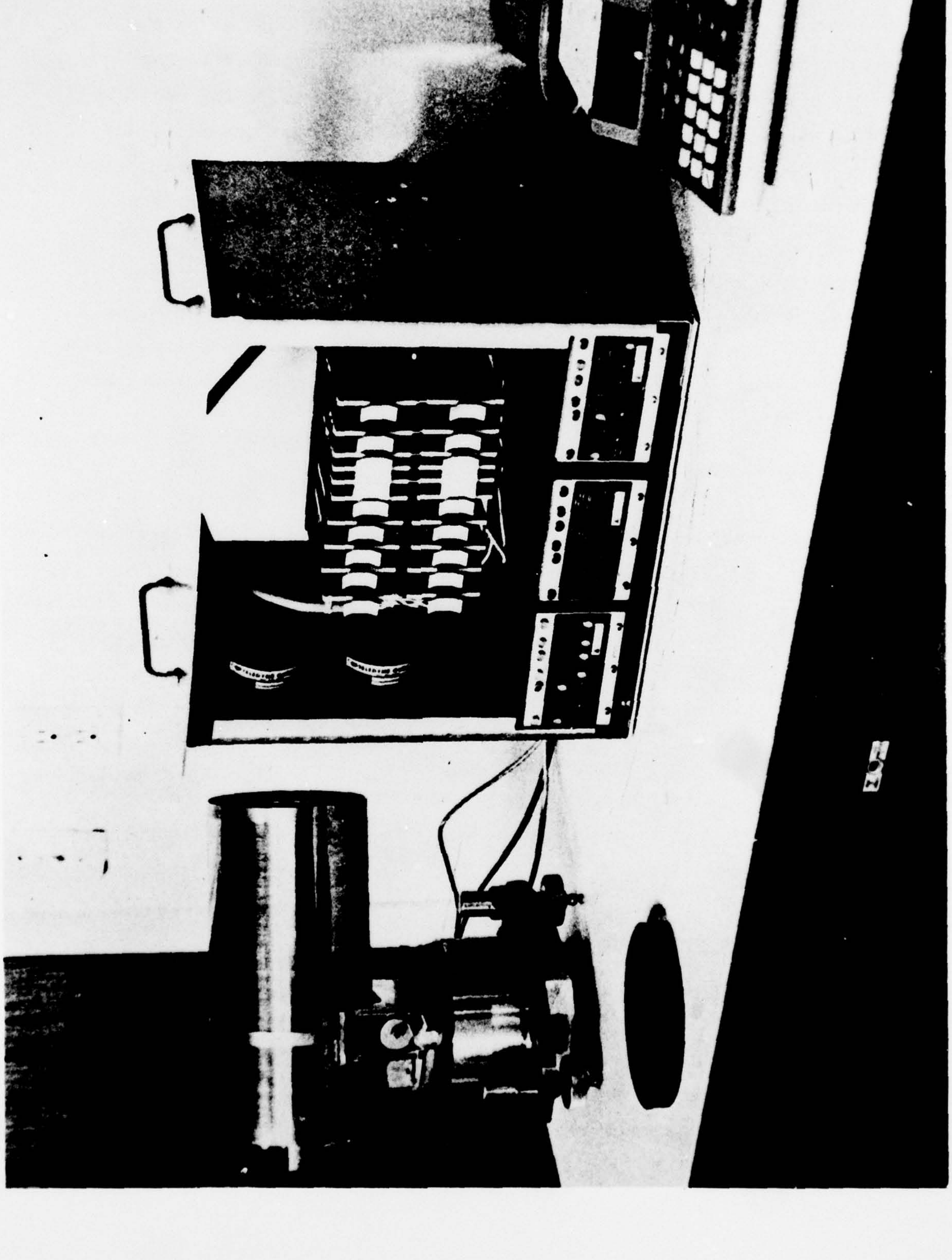

Fig. 1

(b) Precision Azimuth Motion

The precision motion has a range greater than 360° and depends on a 5-inch diameter ultradex for its accuracy. This motion is capable of turning angles with a resolution of one degree with absolute accuracy of approximately 0.1 arcsec. The ultradex is lifted by a gear motor and driven by a torque motor. The motion is encoded by an incremental optical encoder with approximately 4-arcmin resolution to insure proper seating of the ultradex when it is lowered.

(c) Telescope

The telescope is a 5-inch Schmidt Cassegrain used to collect the light from the targets. The light is split into two beams, one for the measuring system and one for initial target acquisition by the operator. The plate scale of the telescope is approximately 3600 arcsec/in.

(d) Focal Plane Stage Assembly

The focal plane stage assembly consists of a linear stage driven by a torque motor and ball screw and encoded by a linear optical incremental encoder having a resolution of 40 microinches. An electromechanical brake holds the motion stationary when it is not being driven. The stage in conjunction with the position sensing diode, which it carries, constitutes the sub-degree or fine angle measuring system.

(e) Level Sensor

An electronically readable level vial is mounted in the horizonatal plane perpendicular to the axis of the telescope. The level readings will be used to compute measurement errors caused by small tilts of the instrument.

2. Electronics Assembly

The electronics assembly consists of a unit containing a card rack, power supplies and cabling and connectors for connection to the calcu-

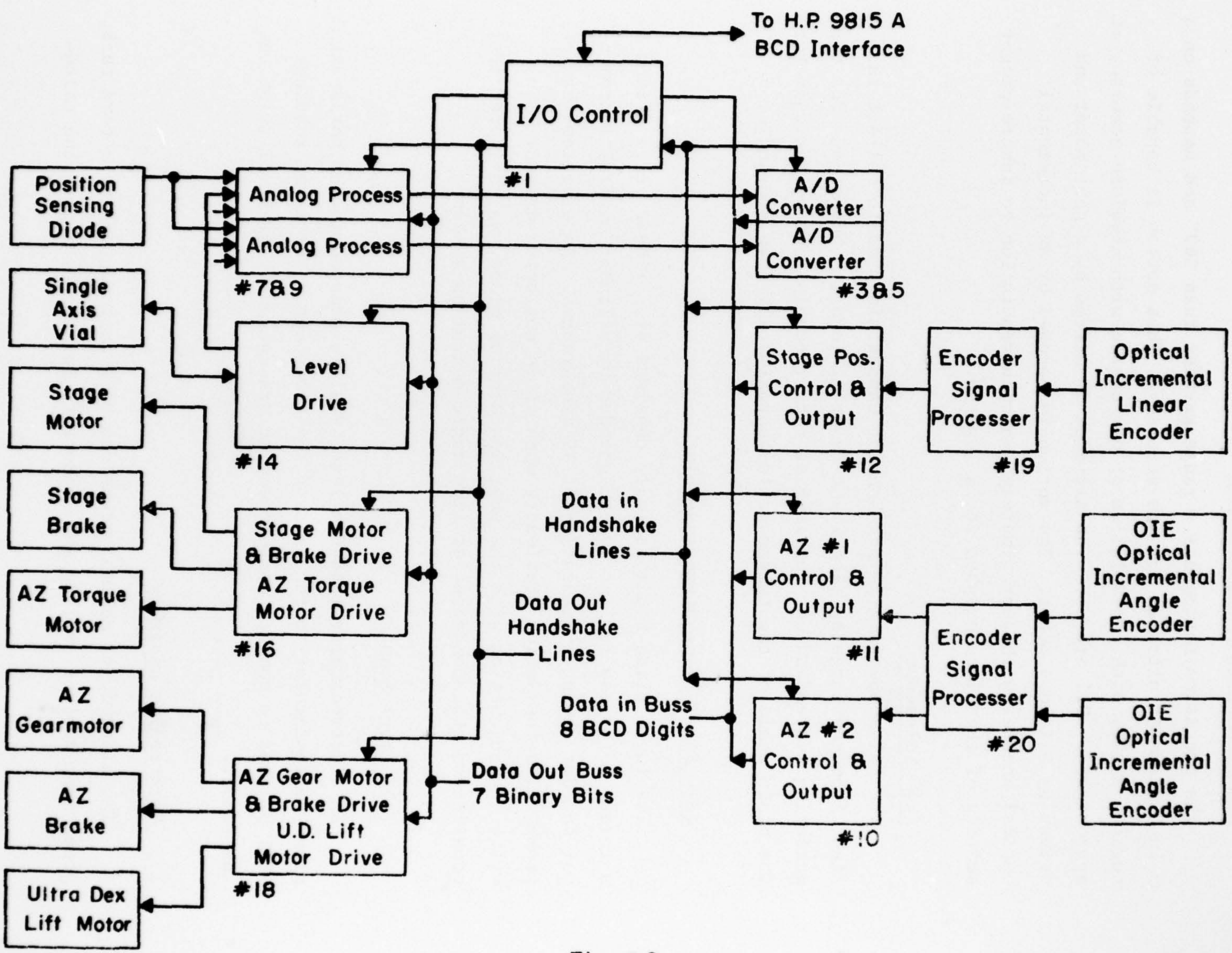
To H.P. 9815 A
BCD Interface
I/O Control
#1
Position Sensing Diode
Analog Process
Analog Process
#7&9
A/D Converter
A/D Converter
#3&5
Single Axis Vial
Level Drive
#14
Stage Motor
Stage Pos. Control & Output
#12
Encoder Signal Processer
#19
Optical Incremental Linear Encoder
Stage Brake
Stage Motor & Brake Drive AZ Torque Motor Drive
#16
Data in Handshake Lines
AZ #1 Control & Output
#11
OIE Optical Incremental Angle Encoder
AZ Torque Motor
Data Out Handshake Lines
Encoder Signal Processer
#20
AZ Gearmotor
Data in Buss 8 BCD Digits
AZ #2 Control & Output
#10
OIE Optical Incremental Angle Encoder
AZ Brake
AZ Gear Motor & Brake Drive U.D. Lift Motor Drive
#18
Data Out Buss 7 Binary Bits
Ultra Dex Lift Motor

Fig. #2

lator interface and instrument head. Figure 2 is a block diagram showing the function of each card in the card rack. The blocks in the outer left and right columns represent devices mounted on the instrument head while all other blocks represent cards in the card rack. The slot number in which the card is installed is indicated at the lower right of each block. Following is a brief explanation of the function of each card.

(a) I/O Control Card #1

The I/O Control Card is a digital multiplexer allowing the calculator to select the cards it will communicate with.

(b) A/D Converter Cards #3 and #5

The A/D Converter Cards each take two card slots due to component thickness. Upon command from the calculator, these cards convert the analog input voltage (0-10 volts) to four BCD digits. The two converters have a single device code and operate simultaneously, the converter in slot #3 putting its output in the four low-order digits of the Interface Buss and the converter in slot #5 putting its output in the next four digits. Thus, after completion of a conversion, eight BCD digits are read into the calculator--four from each converter--resulting from conversions which were done simultaneously.

(c) Analog Processor Cards #7 and #9

The analog processor cards each take two card slots due to component thickness. They accept A.C. input signals and continuously produce an equivalent RMS D.C. output. This output is then input to the A/D Converters allowing the calculator to read A.C. values from the electronic level and the position sensor.

(d) Az #2 Encoder Storage and Readout Card #10

The encoder storage and readout board counts pulses from the incremental encoder signal processor. These pulses are accepted on a count-up input representing clockwise motion and a count-down input representing

counter-clockwise motion. Thus, as the encoder moves, the value accumulated represents the position of the instrument. The calculator can read this value at any time by addressing the card and reading the input buss. Card slot #10 accumulates the count for the lower Az motion.

(e) Az #1 Encoder Storage and Readout Card #11

This card performs the same function as the card in slot #10, except that it accumulates the count for the encoder on the precision one degree Az motion.

(f) Stage Encoder Storage and Readout Card #12

This card performs the same function as the cards in slots #10 and #11, except that it accumulates the count for the linear encoder in the focal plane stage assembly.

(g) Level Drive Card #14

The level drive card produces the A.C. drive signal for the electronic level and amplifies the output signal from the level vial for input to the analog processor card. The level drive card fills two slots because of component thickness.

(h) Torque Motor Drive Card #16

The torque motor drive card supplies drive power of the proper polarity to the Az torque motor on the precision Az motion and the torque motor and brake on the stage in the focal plane stage assembly. The card allows the two motions to be driven in either direction upon calculator command.

(i) Gear Motor Drive Card #18

The gear motor drive card supplies drive power to the lower Az motion gear motor and brake and to the gear motor used to raise and lower the ultradex used in the precision 1-degree Az motion. This card allows these motions to be driven upon calculator command.

(j) Encoder Signal Processor Card #19

This encoder signal processor card accepts signals from the stage linear optical incremental encoder and produces pulses on the proper output line, up or down, each of which indicates a motion of approximately four micro-inches. These pulses are input to the stage encoder storage and readout card.

(k) Encoder Signal Processor Card #20

This card accepts signals from the two Az incremental angle encoders and produces pulses on the proper output lines to the encoder storage and readout cards. Each pulse represents motion of approximately four arcmin.

(l) Photo Detector and Amplifier Card

The position sensitive photodiode and signal amplifier are mounted on focal plane stage assembly. The illumination from the target is focused on the position sensing diode. The resulting output is amplified and routed to the analog processor card.

B. DESCRIPTION OF OPERATION

The measurement of a horizontal angle would be initiated by placing the instrument at the vertex of the angle to be measured and placing illuminated targets with the proper intensity and modulation frequency on the two lines defining the angle.

The present instrument design requires that the three points lie in a horizontal plane since there is no motion about the horizontal axis.

The operator would point the instrument at one of the illuminated targets using the eyepiece to insure that the target is in the field of view. The instrument then would acquire the target and automatically calibrate the fine scale factor against the coarse one. The calibration would be accomplished by using the lower Az motion to position the signal at one edge of the fine or sub-degree range. A figure is then

computed for the instrument heading from the coarse and fine readings. The coarse position is incremented one degree and a new heading computed. A scale factor is then computed to make the two headings equal. This factor would be applied to the fine range for following measurements.

The second target could be acquired automatically or with operator assistance depending on the a priori knowledge of the angle to be measured. After target acquisition a heading would be computed for the second target and the two headings used to compute the measured angle.

The process could then be repeated several times under calculator control. The statistical quality of the data could be determined by the calculator with the measurement automatically terminating when the desired quality is achieved. The measurement data would then be filed on a magnetic tape cassette for easy input to data processing systems.

Theoretical Single Measurement Error

The worst-case error for a single measurement is determined by the error associated with individual components such as the precision azimuth motion, the telescope plate scale, the focal plane stage linear encoder, the position sensing diode, and processing electronics. The dominant error is associated with the signal processing electronics and is equivalent to a peak error of approximately 0.8 arcsec. The error should have a short-term repeatability of about 0.1 arcsec and could probably be modeled and compensated for by the calculator to that level.

C. PRESENT INSTRUMENT STATUS

The instrument has been assembled and testing conducted which indicated the following problems:

The gain of the amplifier following the position sensing diode is not adequate at the desired target modulation frequency of approximately 1 KHz. This would cause trouble on longer lines with less target illumination reaching the instrument. Repeatability problems could also result with changing ambient temperatures since the amplifier gain may be

affected more by temperatue than necessary. The amplifier has been redesigned but no work has been done to construct the new hardware.

The encoder signal processor electronics used between the optical incremental encoders and the position counters have been found to have inadequate noise immunity. They generate spurious input pulses to the position counters causing the position stored there to be in error. Hardware to correct the problem has been built for the two Az encoders, but circuits for the focal plane stage assembly encoder are not yet designed.

The torque motor which drives the precision Az motion has been found to generate inadequate torque to control the motion properly. The motor has been returned to the manufacturer for testing and found to be 30 percent below its specified torque output. Restoring the motor to specs should solve the problem; however no testing has been carried out to indicate that this will be the case.

The problems described above have prevented overall performance testing of the instrument at the present time. Correction of the deficiencies appears to be a relatively minor task. No basic problems have been detected which would prevent the instrument from working in principle.

Illuminated targets are necessary for the instrument to be useful. Work must be done to develop targets capable of producing illumination of suitable wavelength and beam width, and with intensity and modulation frequency control.

D. CONCLUSIONS

It appears that more effort spent in demonstrating the ability of the position-sensing diode as a useful device for measuring angles and saving the automation as a follow-on effort might have been a better approach. However, there is no indication to date that the instrument will not, in principle, function. It seems that, with additional work, the automated single-axis system can be made to function at a useful level.

E. RECOMMENDATIONS

Future effort should be directed toward the development and testing of the position-sensing diode electronics until they are proven to perform at an acceptable level. Work then should continue to automate the measurement process.

APPENDIX A

List of scientists and engineers who contributed to this research project:

John T. Jefferies	Head Scientist
William E. Carter	Scientist
James D. Williams	Engineer
William Cruise	Technician